Next Generation Solid Modellers for Electronic Prototyping

Debasish Dutta
Mechanical Engineering
University of Michigan
Ann Arbor, MI 48109

(313) 936-3567
Email: Dutta@engin.umich.edu

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1. INTRODUCTION

In this research project, we are focusing on expanding the geometric coverage of solid modellers such that a wider variety of objects can be modelled accurately. Solid modellers are large computer programs that enable a designer to construct, interrogate and manipulate computer models of physical objects. They are at the core of every computer system for engineering analysis, prototyping, manufacture and inspection. Various manufacturing tasks can be simulated in the computer and electronic mock-ups (*i.e.*, prototypes) can be created prior to actual manufacture.

The thrust of this project is to alleviate the geometric domain inadequacy of current solid modelers. Towards that end, we are investigating a new class of surface called the (Dupin) cyclide for incorporation into solid modelers. Cyclides have simple and intuitive geometric parameters, they can be represented in both implicit and parametric form, and their offset surfaces are easy to compute. All existing (CSG) solid modeling primitives (*i.e.*, plane, sphere, cylinder, cone and torus) are special cases of the cyclide giving rise to the possibility of a unified framework for surface interrogations, manipulations and intersections within a solid modeler. We have been working closely with Dr. Steve LeClair of the WPAFB in order to address issues of relevance to the Air Force. The applications listed above were

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demonstrated to Dr. LeClair during his visit to our Design Laboratory at the University of Michigan.

2. RESEARCH RESULTS

In the previous year, we developed methodologies for using the cyclide in a solid modelling system to model complex blending surfaces, to assist in pipe layouts, and for synthesizing collision free volumes in 3D. This year, we focused on the design side of things, in that, an algorithm with a simple and effective user interface (we refer to as "circle composition) was developed that enables the construction of tubular surface pieces in 3D. It has been implemented on a Silicon Graphics Personal Iris workstation. Furthermore, on the applications domain, we addressed cable harness design and mold gate design using cyclides. Finally, portability issues of cyclide surfaces to commercial modelers, such as IDEAS, have been addressed. A brief description on each topic follows.

2.1 Circle Composition Scheme

In this project, we developed two synthesis algorithms and two surface editing algorithms. In the synthesis stage, a designer has a 2D user interface in which he can construct planar cross-sectional profiles of the tubular surface by simply putting together circles. In an adjoining window, the 3D surface is automatically generated. This 3D surface is composed of smoothly joined pieces of cyclides. The first algorithm preserves tangent continuity between adjacent pieces by using spherical surfaces. In the second algorithm, the spherical surface are eliminated and cyclide pieces are joined at their circular lines of curvature.

The first editing scheme of such tubular surfaces is enabled by moving one of the three defining spheres of the cyclide. In our implementation, the middle sphere is modified (position and/or size) to modify the entire shape. A more sophisticated method for surface editing has also been developed where double-cyclide blends are used to modify the surface. This provides a better local control of the surface.

2.2 Design of Mold Gates and Cable Harness

The circle composition scheme described above has been applied to two design probelms of interest to the Air Force (WPAFB). The first one is mold gate design. The program can effectively construct mold gates of circular cross section around the mold. A simple mold gate "feature" interface was also added that allows the designer to select and pick gating features such as the spout.

The second application of the composition scheme is in the area of cable harness. An important sub-problem in the design of aircrafts, the routing of cable wires, location of junction points and specification of bend radii are key features that a designer has to deal with. In our implementation, the circle composition scheme can be used as a first cut design tool to evaluate the proper placement of cable wires and junction points early in the design stage. It is easy to modify and manipulate.

2.3 Portability Issues

It is critical to acknowledge and address early on the portability of cyclide surfaces to other commercial modelers. Without a seamless "transfer" of cyclide models to and from commercial modelers, the effectiveness of cyclide surfaces in modeling will be compromised. Therefore, we have developed methods to transfer cyclide models to the commercial modeler IDEAS. Work is ongoing for a complete implementation.

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DR. GUNZBURGER

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University of Michigan
Mechanical Engineering
Ann Arbor, MI 48109

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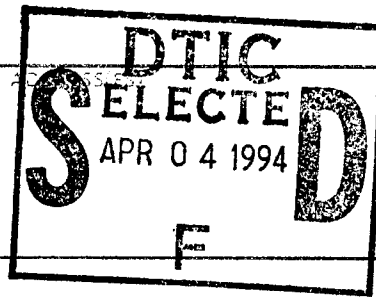
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13. ABSTRACT (Maximum 200 words)

Methodologies for using the cyclide into solid modelling system to model complex blending surface and to assist in pipe layouts have been developed.

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